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FISCAL POLICY EFFECTS IN BRAZIL: VARIABLE TRANSFORMATION AND IDENTIFICATION STRATEGY

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ABSTRACT

This paper seeks to estimate the effects of fiscal policy – government spending and taxes – on Brazilian output. The analysis is based on impulse-response functions (IRFs) derived from a structural vector autoregressive model with three endogenous variables: government spending, output and government receipts. The identification restricted the value of the output elasticity of taxes and assumed that government spending do not respond to the economic environment contemporaneously. The model was estimated assuming two distinct to data generating processes: *a)* the endogenous variables are all unit-root processes; or *b)* the endogenous variables have deterministic trends. The findings are indicative of a negative output response to both spending and tax shocks; that the structural identification results in a counter-cyclical fiscal policy; and finally, that different assumptions about the data generating process generates different IRFs behaviors, especially concerning the response persistence to some shocks.

Keywords: Fiscal Policy; Vector Autoregressive; Brazil.

EFEITOS POLÍTICOS FISCAIS NO BRASIL: ESTRATÉGIA DE TRANSFORMAÇÃO E IDENTIFICAÇÃO DE VARIÁVEIS

RESUMO

Este trabalho buscou estimar os efeitos da política fiscal brasileira – receitas e despesas do governo – sobre o produto. A análise foi baseada em funções impulso-resposta derivadas de um modelo auto-regressivo estrutural, com três variáveis endógenas: gasto do governo, produto e receitas do governo. O processo de identificação restringiu o parâmetro de elasticidade-produto dos impostos e assumiu que o gasto do governo não responde contemporaneamente ao ambiente econômico. O modelo foi estimado para duas suposições distintas de processo gerador de dados: *a)* todas as variáveis são processos de raiz unitária; ou *b)* todas as variáveis possuem tendências determinísticas. Os resultados são indicativos de que o produto responde de forma negativa tanto a choques nos gastos quanto nas receitas tributárias; existe evidência de um política fiscal contra-cíclica, resultado da identificação estrutural utilizada e, finalmente, as diferentes suposições com relação ao verdadeiro processo gerador de dados geram comportamentos distintos nas funções impulso-resposta, especialmente em relação a persistência das respostas aos choques.

Palavras-chave: Política fiscal; Vetor auto-regressivo; Brasil.

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1 INTRODUCTION

The long debate regarding fiscal effects has generated a prolific literature. Efforts to measure fiscal policy can be traced back to the first decades after the World War II, when large structural econometric models of Keynesian inclination where used. More recently, in recent decades, vector autoregressive (VAR) models have become the main econometric approach to assess the effects of fiscal and even monetary policy, since the VAR methodology seems to be more suited to deal with Lucas (1976) critique and Sims (1980) rejection of large and over-identified models. Moreover, the vector autoregressive approach can be directly compared with more theoretical DSGE models: one can, for example, develop a DSGE model using a wide range of assumptions about consumer maximization, price formation, market structure, government sector, and so on, and compare the impulse-response functions (IRFs) of the theoretical models with the impulse-response functions of empirical VAR models with actual data. Specifically, one could compare the IRFs of a DSGE model with government sector with the responses of output and other macroeconomic variables to shocks on fiscal variables in the VAR framework. Fatás and Mihov (2001), for instance, estimate a semi-structural vector autoregressive model to measure the effect of government spending on output, interest and inflation and later comparing their empirical results with a benchmark DSGE model with a government sector (see also Edelberg, Eichenbaum and Fisher, 1999; BAXTER; KING, 2003; BURNSIDE; EICHENBAUM; FISHER, 2004; EICHENBAUM; FISHER, 2004; GALÍ, et al., 2007).

However, even with this relative convergence regarding the method, the same cannot be said about the conclusions. Empirical estimates of fiscal effects using vector autoregressive methodology have often generated conflicting results. The reason behind many contradictory findings is related to *a priori* choices: number of endogenous variables, choice of variables, identification strategy, country choice, period of study, and so on.[3] Compare, for example, the works of Blanchard and Perotti (2002) [BP (2002), in the following] and Mountford and Uhlig (2009). Both estimate fiscal multipliers out of IRFs for the United States using post-World War II

[3] Probably the only consensus so far regards the inclusion of both government spending and taxes as the proper way to measure the effects of fiscal policy using the vector autoregressive framework. With only one dimension of fiscal policy (e.g., deficit), the results are misleading since it assumes a non-existent symmetry between spending and taxes.

data. The first estimates a structural VAR (SVAR) restricting output-elasticity of taxes using external estimation; the second identifies the VAR through a Bayesian approach of sign restrictions on the IRFs. The estimation of the spending multiplier[4] was higher for the first (between 0,9 and 1,29) in comparison with the second (0,65); the tax multiplier was more negative in the second (-3,57) in comparison with the first (between -0,78 and -1,33). Even though both studies agree on the sign of the multipliers, the results are substantially different in the sense that they generate distinct policy implications. As Ramey (2011) stresses, there is a wide interval of estimated effects of government spending; and the same should be true for tax effects. While BP (2002) estimate the benchmark three-variable model (output, spending and taxes) – with expansions to a four-variable model to include GDP components –, Mountford and Uhlig (2009) estimate a ten endogenous variable model (output, spending, taxes, inflation, interest rates, etc.). The effects of fiscal policy on GDP components are even more diverse.

The impact of fiscal policy is even more inconclusive when one goes through the empirical evidence in different countries under different realities. Using the same SVAR methodology of BP (2002), Perotti (2004) studied the impulse response functions of government spending and taxes on macroeconomic variables of five OECD countries, finding that spending effects were usually small (output multiplier less than 1) and sometimes negative; tax shocks also had reduced responses and in some cases with opposite sign than expected. Perotti (2004) also found that fiscal policy effects got weaker over time.[5] The causes of such diversity of output responses to fiscal stimulus began to be better understood from the results of Ilzetzki (2011) and Ilzetzki *et al* (2013), that use the vector autoregressive methodology to a broad sample of countries, highlighting that countries do have distinct responses to fiscal shocks depending on some broad characteristics: developed countries tend to show significant responses to fiscal stimuli, while developing countries had non-significant or even negative multipliers; countries in fixed exchange rate regimes had significant output responses, while countries with flexible exchange rates had zero response; open economies have smaller responses in comparison to closed ones

[4] That is, increase of output (in dollars) in response to one-dollar increase in government spending.
[5] Perotti (2004) compared IRFs of two sub-periods: the first roughly from 1961 to 1980; the second roughly from 1980 to 2001.

and, finally, high debt countries face negative multipliers.[6] Other authors have stressed the importance of the timing and non-symmetrical effects of fiscal policy regarding the sign and magnitude of the shocks and the phase of the business cycle (AUERBACH; GORODNICHENKO, 2010; BAUM; KOESTER, 2011; GOGAS; PRAGIDIS, 2014).

Similar conflicting results found in the international empirical literature of fiscal policy effects (estimated through vector autoregressive models) can be found in Brazilian literature. As the next few paragraphs will show, empirical findings for the Brazilian case also range from the traditional Keynesian-like responses of output (positive for spending, negative for taxes) to cases where tax hikes can have expansionary results. Contrary to a large body of research internationally – especially among OECD countries – there is not a quite large research effort at the national level to empirically assess this issue, though. On this subject, the works that use IRFs to assess the effects of fiscal policy and that should be the ones this work might be compared to are the structural estimations of Peres (2006, 2012) and Peres and Ellery Jr. (2009), Cavalcanti and Silva (2010) and Correia and Oliveira (2013); and the Bayesian sign-restriction methodology of Mendonça *et al.* (2009). The remaining of this introduction tries to briefly review each of these, and finally points some remaining issues that should be addressed to the better understanding of the problem in the Brazilian context, and where lies the contribution of this research.

Peres (2006) and Peres and Ellery Jr. (2009) estimated a SVAR model with three endogenous variables: output, government spending and taxes. They used quarterly data for the period 1994:1-2005:2. The fiscal variables covered central government spending and receipts on account of a lack of official estimates of consolidated government spending. Also, Peres (2006; 2012) estimated federal fiscal variables net of transfers (benefits, unemployment security, etc.), getting close to the definition of BP (2002). The output was the only variable identified as unit-root process by traditional tests, and for that reason was inserted as first-difference (rate of growth) in the model. Fiscal variables, on the other hand, were inserted in levels (identified as stationary). The estimated IRFs showed that government spending shocks had positive effect on output and tax shocks had negative effects – the first

[6] Even though not using VAR methodology, Giavazzi and Pagano (1990) and Alesina and Perotti (1997) present cases of "expansionary fiscal consolidations", i.e., when a fiscal adjustment (rise in taxes, reduction of spending) expands output and its components.

shock being stronger than the second. But the responses were not persistent: the output response was significant only through the first quarter after the tax shock; and the spending shock, only at the impact. Peres (2012) extended the period of analysis (1994:1-2012:1) and measured the impact of fiscal policy on GDP and its components (consumption, investment, exports and imports). Interestingly, the effects on output are very similar to those found earlier, indicating a degree of stability of output responses to fiscal shocks. It is necessary to stress that Peres (2006) also estimates the output-elasticity of taxes (or, output-tax elasticity) – using an approach similar to BP (2002) – to identify the structural model. The same value will be used as a reference in the following sections to derive structural errors and structural impulse-response functions.

Cavalcanti and Silva (2010) main SVAR estimates and conclusions is also founded in the three endogenous variable model of spending, output and taxes. The main objective, though, is the comparison of the model with and without public debt included as an exogenous variable. The estimation covers the period from the first quarter of 1995 to the forth quarter of 2008, using the calculations of consolidated tax receipts of Dos Santos and Costa (2008) and a recovered series of consolidated government spending.[7] There is no analysis of the data generating process (DGP) of the set of endogenous variables, i.e., no tests to check for the presence of unit-root processes and, consequently, no transformations before inserting the variables into the model (all variables were inserted in levels). IRFs were derived through Choleski decomposition, ordering government spending first, output second and taxes last.[8] Besides the problem of the confidence intervals being too large, the results show that the effects of government spending are much less strong and less persistent in the model with debt in comparison with the model without debt. On the other hand, the effects of tax shocks on output are more negative without debt. In the model with debt a positive tax shock could generate even a positive response after more or less eight quarters, and significantly so. The impulse-response functions also show that spending responses to tax shocks tend to be stronger and more persistent: probably through a relaxing effect on government's budget constraint. Cavalcanti and Silva

[7] The recovered consolidated government spending series is a residual from Brazilian Central Bank's series of primary deficit series and the tax receipts series of Dos Santos and Costa (2008).

[8] The authors performed sensibility analysis for different structural identification strategies, but the reference model is a Choleski decomposition.

interprets the less depressing effect of tax increases in the model with debt coming from the greater increase in spending permitted by the relaxation of budget constraint; but since the direct effect of spending is virtually nil, a more plausible explanation would give more importance to a consistent improvement in expectations regarding public finances.

Correia and Oliveira (2013) relax the previous assumption of public debt being an exogenous variable. The estimation using structural vector autoregressive approach with monthly data (1995:1 to 2012:10) includes debt as an endogenous variable, together with output, spending, interest and inflation rates. The primary objective of their work is to compare changes on IRFs dynamics due to the changes in fiscal rules with the sanction and enforcement of brazilian fiscal responsibility legislation, that meant the imposition of limits to central, state and local government spending with employees, accumulation of debt, and so on, and steps towards more transparence of public finances.[9] Correia and Oliveira (2013) estimate the first model without debt, with four endogenous variables: product, government spending, interest rates and inflation. The second model includes public debt as the fifth variable. Both models are estimated with and without a dummy variable to capture the structural change caused by the new legislation. More important here is the comparison of the spending shock between the models with and without debt as an endogenous variable: without debt, the spending shock was significant in the first five or more months, while the inclusion of debt makes the fiscal policy effect significant only at impact, or not significant at all, depending on the structural identification strategy. The results should be interpreted with care, though, since the different models – beyond the many identification strategies – included only government spending as the instrument of fiscal policy.

Only the work of Mendonça *et al* (2009) diverges from the basic SVAR approach. They apply the methodology developed by Mountford and Uhlig (2005; 2009) to measure the effects of fiscal policy on output, private consumption, inflation rate and interest rate; during the period 1995:1-2007:12. The Bayesian approach identifies the structural shocks imposing sign restrictions on IRFs instead of imposing restrictions on the structural matrix. The fiscal variables comprehend the consolidated government receipts and the consolidated government spending (both

[9] See Nascimento and Debus (2003) and Giambiagi and Além (2011, Ch. 7).

as a share of GDP). All variables enter the model in levels. Estimated IRFs are indicative of a negative spending multiplier: a positive shock in spending generates a positive response on consumption and interest, and a negative response on output – probably the result of a depressing effect on the private investment coming from a large *crowding-out* effect (interest rates rises). The positive shock on taxes seems to have a negative effect on output at the impact, but soon the response switch to be positive and remains so. Also, the tax shock is accompanied by a negative response of spending. This puzzling pattern of fiscal contraction with expansionary effects might be interpreted in a similar fashion as in Cavalcanti and Silva (2010): a positive tax shock tends to improve government budget constraint and expectations, indirectly causing a positive effect on output. The spending and tax responses to output shocks are indicative that the Brazilian fiscal policy is generally pro-cyclical.

The last few paragraphs outlined the major works that tried to measure fiscal policy in the Brazilian empirical literature using the vector autoregressive approach. As already stressed, one can promptly notice the lack of consensus: there was not a convergence of evidence point to a particular response of output to, say, a tax shock; the spending shock varied from significantly positive to no significant at all. The objective of this work is to contribute to this literature. Moreover, as important as those earlier works may be, a closer analysis will show that the research in fiscal policy analysis still have wide possibilities, as some gaps remain open. This study main contribution is to show that output responses can change greatly depending on some basic DGP assumptions. The literature outline above – as least Mendonça *et al.* (2009), Cavalcanti and Silva (2010) and Correia and Oliveira (2013) – paid little attention to the problem of non-stationarity of the endogenous variables. Only the work of Mendonça *et al* (2009) could be based in a more rigorous methodology that permits this kind of procedure. Instead, classical econometric theory – including classical textbook vector autoregressive methodology – assumes always a vector of stationary variables, which guarantees a stable model to work with. Peres (2006; 2012) and Peres and Ellery Jr. (2009) were the only ones that performed unit-root tests, and even so only the traditional Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests.

The empirical analysis of the next sections shows that the decision to assume the endogenous variables as unit-root processes or not (trend-stationary or even stationary) makes much difference. The behaviors of the estimated IRFs under each assumption – stochastic trend or trend-stationary – are quite different, at least in terms of the persistence of fiscal policy. Even granting the arguments in favor of diminish the unit-root problem, as given, for example, by Cavalcanti and Silva (2010), one should bear in mind that the choice will have effects on the results. A secondary contribution is the sensibility analysis carried out on the output-elasticity parameter calculated by Peres (2006). There is indication that variation of this parameter interacts with the DGP assumption, having implications on both the magnitude and the persistence of the responses.

In Section [3], therefore, Figures [1] to [3] present two separate types of IRFs: a block of responses assuming that all variables (spending, output and taxes) are unit-root processes, i.e., all three variables have stochastic trends (left); and a block of responses that presupposes that the variables have, in fact, deterministic trends (right). Afterwards, a sensibility analysis on the value of the output-tax elasticity in carried out, assuming alternative values that rages from 1 to 4 (the reference value of 2 was used, following Peres (2006)). Naturally, the sensibility analysis was carried out on both DGP assumptions. The accumulated results can be grouped in four broad conclusions. First, fiscal policy effects are indeed sensible to assumptions regarding the nature of the trend – whether stochastic or deterministic. There is a pattern that shocks under trend-stationarity assumptions are more long-lived, whether in relation to the dynamics of the output in response to fiscal shocks or the capacity of each shock to perpetuate itself; second, the output responses to both spending and tax shocks are negative, i.e., the increase in tax and spending do have a depressing effect on output; third, the higher the output-tax elasticity, stronger will be the negative response of output to taxes, and more short-lived will be the business cycle; four, the structural model with a high output-tax elasticity gives evidence of a counter-cyclical fiscal policy operating through a high response of taxes – together with a insignificant response of spending – to an output shock.

2 METHODOLOGY AND DATA

2.1 Method

This section presents a brief outline of the methodology used to identify a structural vector autoregressive model under the hypothesis of stationarity and stability. The estimation of reduced-form vector autoregressive models actually hides implicitly a structural form that gives account of the contemporaneous effects. Making these contemporaneous effects explicit, one can express the vector autoregressive approach in the following way:

$$Ay_t = Av + A\lambda(L)y_{t-1} + B\varepsilon_t \qquad [1.1]$$

$$Au_t = B\varepsilon_t \qquad [1.2]$$

Where *y* is a *k*-order column vector of endogenous variables; v is a *k*-order column vector that could include, beyond a constant, deterministic components such as trend, seasonal dummies and maybe exogenous structural breaks; $\lambda(L)$ is a polynomial lag function where each element of the polynomial is a $(k \times k)$ matrix;[10] and A is the *structural matrix* containing the contemporaneous relationships; u_t is a white noise *k*-order column vector $[E(u_t) = 0;\, E(u_t u'_t) = \Sigma_u;\, E(u_t u'_s) = 0 \;\forall\; \mathrm{s} \neq \mathrm{t}\,]$ and Σ_u assumed to be a positive semidefinite, symmetric and non-singular. The structural error column vector ε_t is a white-noise, but with unit-variance and no cross-correlation $[\Sigma_\varepsilon = I]$. The B matrix specifies the contemporaneous impacts of structural shocks (ε) on reduced-form shocks (u). Often, the B matrix is set to be a diagonal matrix.

Only after pre-multiplying the reduced-form model by the structural matrix is possible to derive meaningful impulse-response functions: the reduced-form errors are correlated (variance-covariance matrix Σ_u has off-diagonal non-zero entries) and it would actually be misleading to force a shock in one variable (say, a shock in government spending) – maintaining all other variables shocks equal to zero (say, government taxes) – seeking to measure the impact of the supposed exogenous shock on the system. Identifying contemporaneous correlations and, therefore, the vector ε_t, one can finally use the *ceteris paribus* concept on the shocks. The

[10] That is, $\lambda(L) = \sum_{i=1}^{k} \lambda_i L^i$, where each λ_i is a $(k \times k)$ matrix.

structural matrix, however, is not unique. Several methods of identifying the structural shocks were proposed.[11]

Since the objective here is to apply the VAR methodology to measure fiscal policy effects, let's put the issue of identification into perspective. The simplest and common VAR model of fiscal policy is the three-variable model where the vector of endogenous variables is $y = (g, \tau, y)^T$ – g being the measurement of government spending; τ being the measurement of government receipts (taxes); and y being a measure of total output of the economy. Equation [1.2], then, could be re-written in matrix form as:

$$Au_t = B\varepsilon_t$$

$$\begin{bmatrix} 1 & -\beta_{gy} & -\beta_{g\tau} \\ -\beta_{yg} & 1 & -\beta_{y\tau} \\ -\beta_{\tau g} & -\beta_{\tau y} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^y \\ u_t^\tau \end{bmatrix} = \begin{bmatrix} \gamma_{gg} & \gamma_{gy} & \gamma_{g\tau} \\ \gamma_{yg} & \gamma_{yy} & \gamma_{y\tau} \\ \gamma_{\tau g} & \gamma_{ty} & \gamma_{\tau\tau} \end{bmatrix} \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^\tau \end{bmatrix} \qquad [2]$$

The structural VAR approach accomplishes identification through imposition of values on matrices A and B. Firstly, one seeks to impose zeros on some components of the matrices using, if possible, economic theory, but not necessary giving a recursive structure to the model. If one imposes enough zeros, one can achieve identification. In fact, many empirical works do just that – for example, Cavalcanti e Silva (2010) and Correia and Oliveira (2013). But clearly, it is possible to impose other values. The structural estimation for the U.S. economy proposed by BP (2002), there is also imposition of zeros on some coefficients of the structural matrix and almost on all coefficients of the B matrix. Their assumption, which is used here, is that government spending innovations are not influenced by change on the economic environment (taxes and output), i.e., $\beta_{gy} = \beta_{g\tau} = 0$. Those restrictions can be grounded on the assumption that government does not have the ability to immediately respond – due to the high-frequency nature of the dataset.

The crucial imposition on the structural matrix made by BP (2002) refers to the output-elasticity of taxes (output-tax elasticity) – given by the second column of the

[11] One can identify the structural matrix through Choleski decomposition (recursive method) and the structural approach. The methodology of signs restrictions of Mountford and Uhlig (2009) also can be used to identify structural shocks. See Caldara and Kamps (2008) for a vector autoregressive application of the three methods to assess fiscal policy effects on the US economy.

third row in Equation [2] – that measures the contemporaneous effect in taxes due to output innovations. Impose a zero value on this coefficient is highly implausible. Yet, letting it to be a free parameter means imposition elsewhere – the estimated Σ_u matrix has only $[(k^2+k)/2]=6$ distinct values, giving the possibility of the same number of free parameters in Equation [2]. BP (2002) takes another route and use outside estimation of the output-tax elasticity and imposes it on $\beta_{\tau y}$.[12] As already noted, Peres (2006) calculated the output-tax elasticity for the Brazilian economy during the 1994:1-2005:2 period, arriving at $\beta_{\tau y}\cong 2$. The empirical application in the next section will profit from this estimation as well. Outside estimation of $\beta_{\tau y}$, together with the institutional restrictions referred above, and the assumption that each structural shock has its effects only on its own variable, complete the necessary numbers of restrictions to identify the model: 6 distinguished (estimated) parameters of the reduced-form covariance matrix are associated with three free parameters in each matrix, A and B. Applying the aforementioned restrictions in Equation [2] one gets:

$$A^{*}u_t = B^{*}\varepsilon_t$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -\beta_{yg} & 1 & -\beta_{y\tau} \\ -\beta_{\tau g} & -\boldsymbol{\beta_{\tau y}} & 1 \end{bmatrix} \begin{bmatrix} u_t^g \\ u_t^y \\ u_t^\tau \end{bmatrix} = \begin{bmatrix} \gamma_{gg} & 0 & 0 \\ 0 & \gamma_{yy} & 0 \\ 0 & 0 & \gamma_{\tau\tau} \end{bmatrix} \begin{bmatrix} \varepsilon_t^g \\ \varepsilon_t^y \\ \varepsilon_t^\tau \end{bmatrix} \qquad [3]$$

All zeros and $\boldsymbol{\beta_{\tau y}}$ $(=2)$ are restricted values. With an external value of the output-tax elasticity, it is possible to set the contemporaneous effect of taxes on output ($\beta_{y\tau}$) a free parameter instead of zero, as Equation [3] shows. Structural errors derived from Equation [3] can finally be used to estimate structural IRFs.

Notwithstanding, the methodology outlined above holds good especially when the dataset is composed of stationary series. This lack of attention with the series DGP and the stability (stationarity) of the VAR model was rather the rule than the exception in Brazilian literature, as the introduction shows. Giving the fact that output, government spending and tax receipts are all non-stationary series, it is imperative to

[12] See Blanchard and Perotti (2002) appendix for detail. To arrive at a reasonable value of $\beta_{\tau y}$, it is necessary to calculate the tax-base-elasticity of taxes and the output-elasticity of tax base, for each component of taxes. See Cohen and Folette (2000) and Giorno *et al.* (1995). See Enders (2015, Ch. 5) and Lütkepohl (2007) for more on VAR methodology.

transform them in a way to insert only stationary variables in the vector autoregressive model. The strategy, then, will be to generate two blocks of IRFs: in Figure [1] to [3] the stochastic-trend assumption block will be on the left-side and the determinist-trend assumption will be on the right side. The strategy of estimating IRFs for both assumptions is supported by the fact that several formal unit-root tests were applied to the series, without unambiguous conclusions about this issue.[13]

2.2 Data

The next section's adaptation of BP (2002) model benefits from a larger dataset than the previous vector autoregressive works reviewed in the introduction. However, there is need to highlight some adjustments made that were necessary in order to arrive at a good application of the model to the Brazilian context. All conclusions of this study should be understood having in mind the data limitation of Brazilian macroeconomic data. First, official Brazilian quarterly macroeconomic variables are available since 1995 onwards. This puts applied research in Brazil in a obvious disadvantage in relation to a few OECD countries with long datasets – US quarterly macroeconomic data goes back to the 1950s, for example – making the estimation less robust: from 1995:1 to 2014:3 there is a total of only 79 observations (the degrees of freedom should be much less, depending on optimal number of lags on the autoregressive model). Second, data limitation is even more problematic in the case of the fiscal variables: Brazil has a good and relatively transparent fiscal statistics only for the central government sphere, meaning that time series of the consolidated government sector is completely absent – leaving the research with little choice but to use central government datasets to maximize the sample size.[14] The alternative strategy of using unofficial series could do more damage than good. Take,

[13] The authors tested the seasonally adjusted logarithmic transformation of output, spending and tax receipts series (as defined in Section 2.2) using several unit-root tests, that included the traditional ADF, PP and DF-GLS (tests without breaks); and the more modern Zivot and Andrews (1992) and Clemente et al. (1998) endogenous-break tests.

[14] Except for the case of primary and nominal deficit of the consolidated government (central, state, local and government enterprises), which can be recovered by the variation of public debt. Brazilian Central Bank is responsible for gathering this information and making it available to the public. A first approximation to consolidated government receipts for a shorter period (1995:1 to 2007:4) was calculated by Dos Santos and Costa (2008). To the best knowledge of the authors, there has been no official effort to estimate any good approximation of the consolidated government spending. As stressed earlier, Cavalcanti and Silva (2010) seems to have tried to retrieve the spending series from the Central Bank's primary results statistics and the receipts series from Dos Santos and Costa (2008); Mendonça et al. (2008), on the other hand, used an unofficial estimation of consolidated government spending from the National Treasury through direct contact with this institution.

for example, the receipts of the consolidated government sector calculated by Dos Santos and Costa (2008): using it would reduce the sample size to the period between 1995:1 and 2007:4, giving up to many degrees of freedom in a context of an already reduced sample size in comparison with other countries. This is probably the reason why Peres (2012) also limited his research to measure the dynamic effect of central government's fiscal shocks.

The Brazilian National Accounts System– *Sistema de Contas Nacionais* (SCN) – makes available nominal GDP series from the first quarter of 1995 until the third quarter of 2014. It is possible, for that same initial period, to construct quarterly data for the fiscal variables from the treasury execution of the federal government – which monthly current figures are available at the Central Bank database – that measures the federal government receipts and disbursements (not counting social security and central bank results) through the Treasury. The original GDP series and the constructed fiscal series were then deflated by the quarterly accumulation of IGP-DI price index.[15] Finally, ARIMA-X12 method and logarithmic transformation were then applied.

Unit-root tests were conducted on the seasonally adjusted logarithmic transformation of output (GDP) and government spending and receipts (again, Treasury execution). Since traditional tests usually give biased results toward non-rejection of the null (of unit-root), on top of ADF, PP and DF-GLS tests, the endogenous-break tests of Zivot and Andrews (1992) and Clemente *et al.* (1998) were performed.[16] The accumulated evidence leans toward accepting the null hypothesis of unit-root. Nonetheless, a thorough analysis would show that there is no unambiguous response to the question of whether the output and fiscal variables are in fact unit-root processes or not: even the logarithm of the output series, which could not be regarded as trend-stationary by any *t-statistic* have autoregressive estimates well below unit, giving clear indication of the low power in all cases. The results are even more problematic for the fiscal variables, with some tests pointing in the direction of unit-root, while others rejecting this hypothesis in favor of the alternative hypothesis of trend-stationarity. This incapacity of formally stating the true data generating process of the series under study justifies the strategy of calculating the

[15] *Índice Geral de Preços – Disponibilidade Interna*. From *Fundação Getúlio Vargas* (FGV).
[16] See Enders (2015, Ch. 4) for a brief discussion of analyzing series with structural change. The tests results, however, were not reported here due to space limitations. They are available upon request.

vector autoregressive models under each hypothesis and analyze if there is evidence of distinct behavior between such different IRFs constructions.

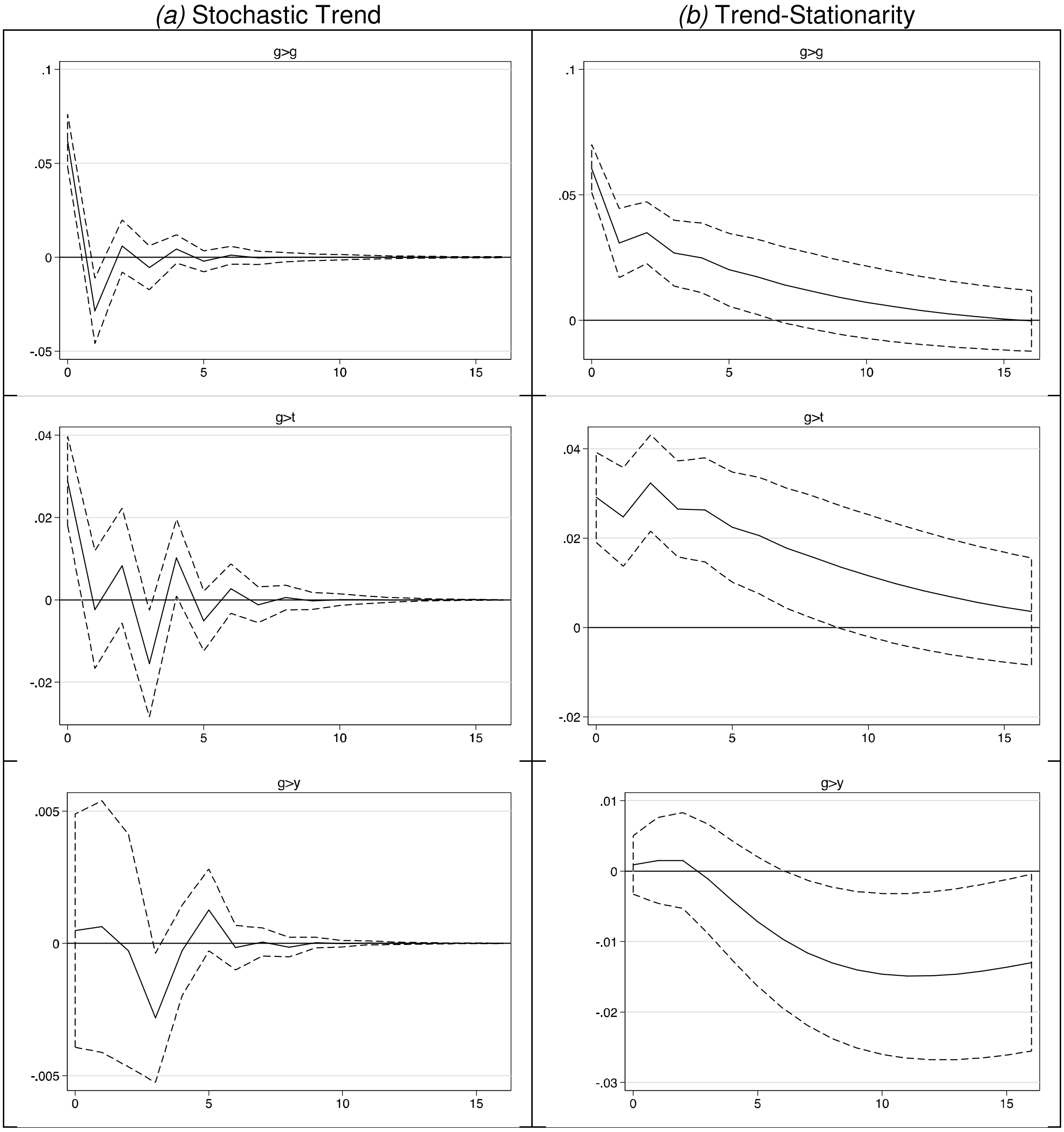
3 RESULTS

3.1 Structural model

Figures [1] to [3] exhibits the IRFs imposing the contemporaneous structure outlined in Equation [3]: no contemporaneous effects of output and taxes on government spending and restriction of the output-tax elasticity, $\beta_{\tau y} = 2$. Panel *(a)* presents the IRFs derived from the VAR estimation using first-differentiated variables; panel *(b)* presents IRFs derived from estimation using de-trended series. The maximum likelihood estimation of the structural matrix and several diagnosis tests (optimal lag selection, serial autocorrelation and stability) are available on request. The optimal lag choice according to AIC and BIC information criteria was 2. Figures [1] to [3], then, give IRFs of a second-order VAR model with bootstrap confidence intervals.

Figure [1] presents the responses to a shock on government spending. It is striking the differences between the responses persistence to shocks depending on the DGP assumption. Panel *(a)* spending response to its own shock is significant only at impact and after one quarter; the tax response is significant on impact, turn to insignificancy afterwards and present a smaller significantly negative value at the third quarter; the output response is positive but insignificant at impact, and also presents a slightly negative and significant response at the third quarter (probably the reason why tax receipts response also turn negative at that same quarter). Panel (*b)* shows more persistent responses and interesting results. Spending own response has a positive peak on impact, but with slow decay, remaining positive and significant up to the seventh quarter; tax receipts have maximum response at the second quarter after the initial shock and remains significant for nine quarters; the output response is initially positive, albeit not significant, turns negative at the third quarter, negative and significant from the seventh quarter until the end of the sixteen-period horizon.

Figure [1] –Responses to spending shocks

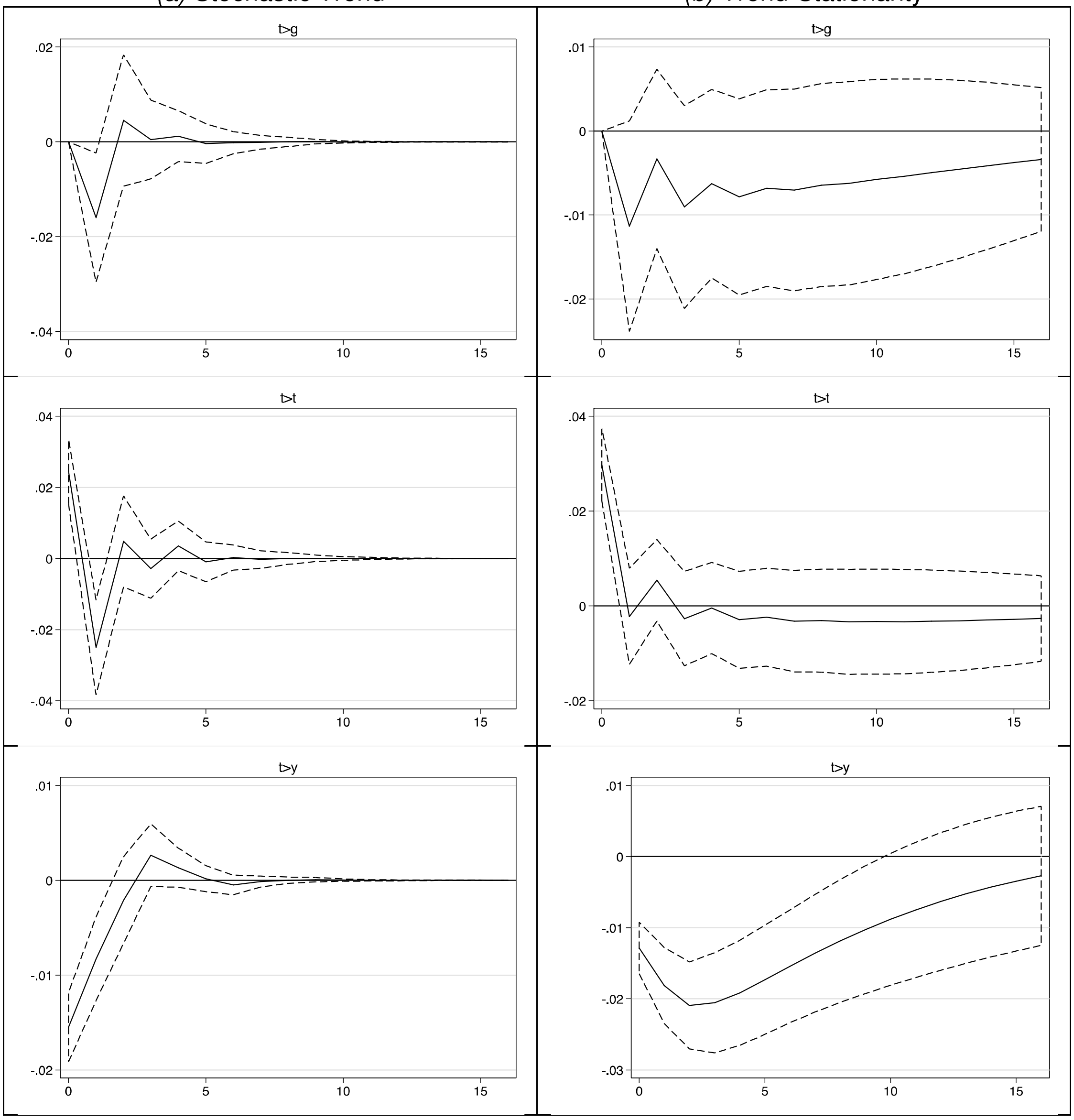


Source: Authors' calculations.

Notes: **I)** Bootstrap confidence intervals. **II)** Identification attained restricting the following parameters as: $\beta_{gy} = \beta_{g\tau} = 0$ and $\beta_{\tau y} = 2$ (see Equation [3]). **III)** Assumptions: panel *(a)* – stochastic trend (first-differentiated variables); panel *(b)* – deterministic trend (de-trended variables).

Figure 2 – Responses to tax shocks

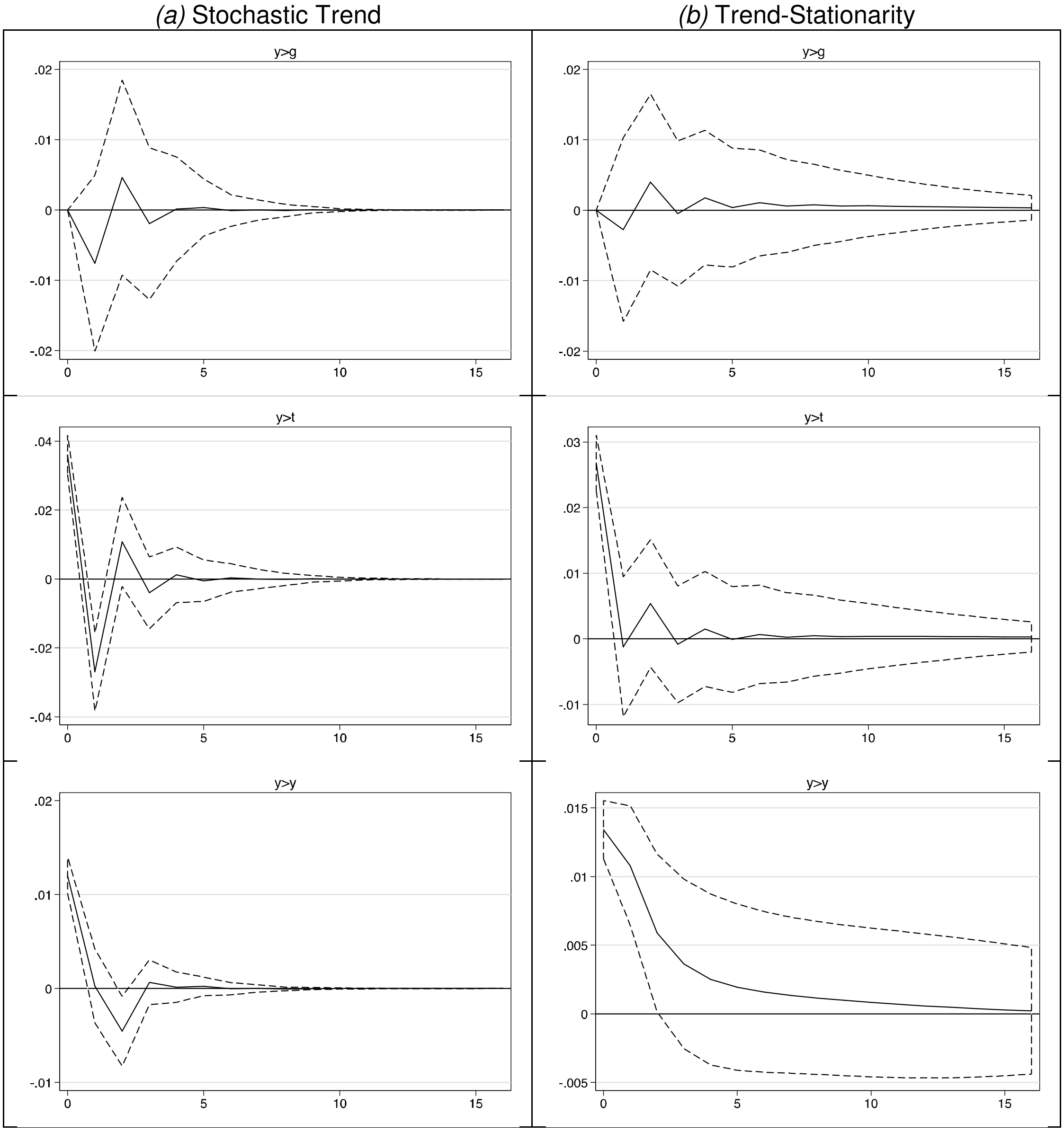
(a) Stochastic Trend *(b)* Trend-Stationarity



Source: Author's calculations.

Notes: **I)** Bootstrap confidence intervals. **II)** Identification attained restricting the following parameters as: $\beta_{gy} = \beta_{g\tau} = 0$ and $\beta_{\tau y} = 2$ (see Equation [3]). **III)** Assumptions: panel *(a)* – stochastic trend (first-differentiated variables); panel *(b)* – deterministic trend (de-trended variables).

Figure 3 – Response to output shocks



Source: Author's calculations.
Notes: **I)** Bootstrap confidence intervals. **II)** Identification attained restricting the following parameters as: $\beta_{gy} = \beta_{g\tau} = 0$ and $\beta_{\tau y} = 2$ (see Equation [3]). **III)** Assumptions: panel *(a)* – stochastic trend (first-differentiated variables); panel *(b)* – deterministic trend (de-trended variables).

The structural responses to a tax shock are given in Figure [2]. The spending response to a positive tax shock is negative under both DGP assumptions, though significant (marginally) only in the first quarter after the impact in the case of panel *(a)*. The response in panel *(b)* is always negative but no significant at all. The output response, under stochastic-trend assumption, shows that growth collapses at the time of the shock, and remains low in the next quarter. Under trend-stationarity, the shock makes the output to remain below trend for about nine quarters and with maximum (negative) impact at the second quarter after the initial shock. The tax response to its own shock is highly significant positive but dissipates relatively quickly: in the stochastic case, there is a negative rebound in the quarter after the shock (not strong enough to neutralize the initial positive response) and then turns to insignificancy; under trend-stationarity assumption, only the response at the time of the shock is significant.

Figure [3] plots the responses to an output shock. In both DGP assumptions the shock generates insignificant spending responses. Panel *(a)* shows a positive tax response at impact and a negative response at the first quarter. This negative setback at the first quarter is not sufficiently strong to reverse the initial positive dynamics, similarly to the tax response to its own shock in Figure [2]. Output response is also positive at impact and slightly significantly negative after two quarters – also with positive net response. Panel *(b)* tax response is highly positive at impact, but with no persistence at all – turning to insignificancy from the first quarter onwards; output response, on the other hand, has a positive and significant peak at impact; decaying from the first quarter onwards and becoming insignificant at the third quarter after the initial shock.

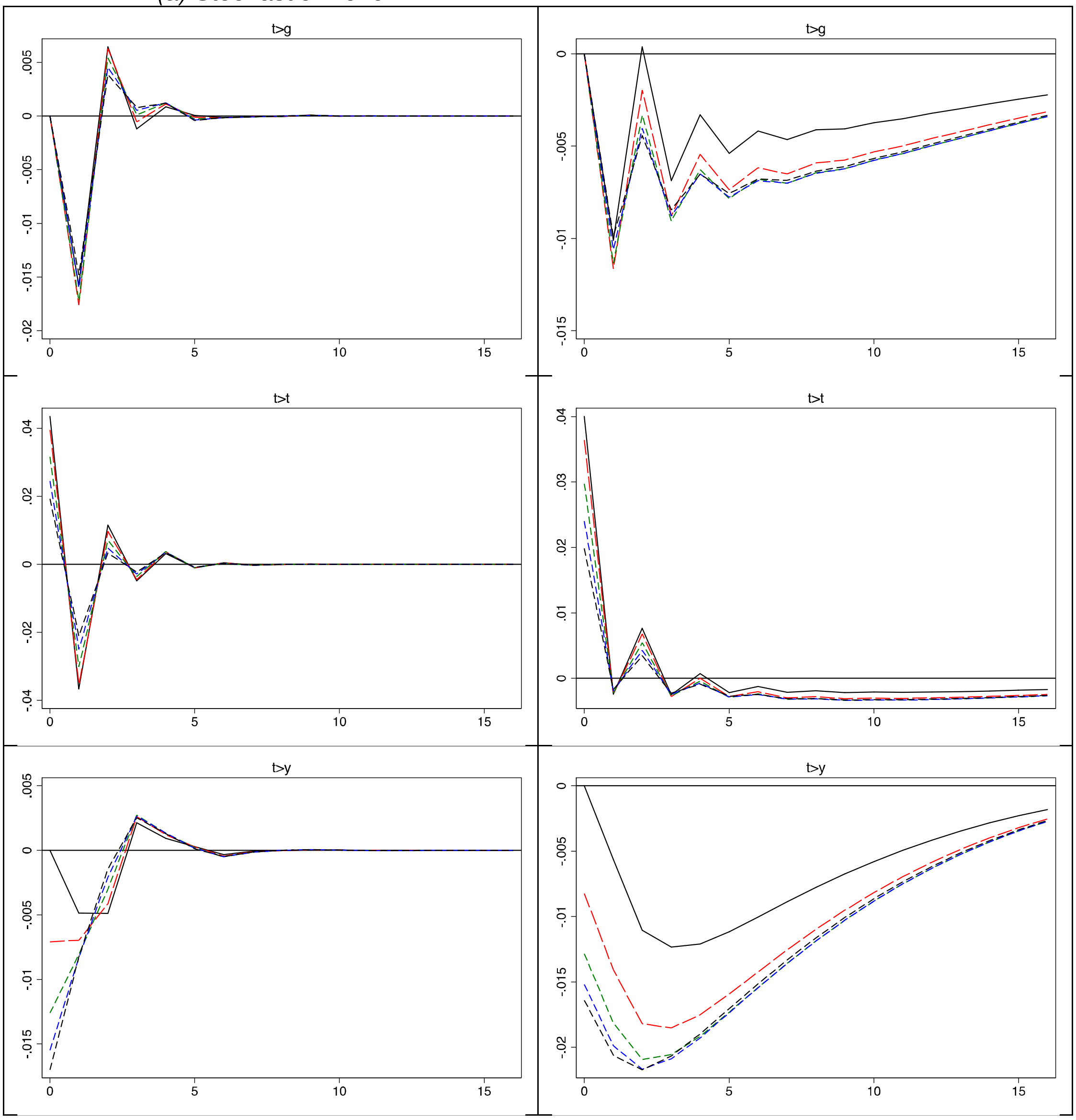
The accumulated evidence from the structural IRFs of Figures [1]-[3] are very interesting. First, trend-stationarity assumption tends to give more persistent net responses to shocks, especially output responses to spending and taxes; the structural model – with its high output-tax elasticity – suggests that Brazilian central government could have been operating a counter-cyclical fiscal policy, result of this high output-elasticity of taxes in conjunction with a weak instantaneous response of government spending to these same shocks. Also, the high output-tax elasticity seems to influence the business cycle self-propagation mechanism making it very short-lived; thirdly, both the positive shocks on spending and on taxes have generated negative responses of output that lasted for several quarters in the case of trend-stationarity; and last, one could also make the case that positive tax shocks are associated with negative spending responses, giving some indication that tax hikes and spending reductions go together: probably the result of a further effort to improve the government ‘s budget constraint.

3.2 Sensibility analysis

So far, the analysis shows that the effects of fiscal policy – and the implied response of fiscal policy to business cycles shocks – depends strongly on the assumptions about the data generating process on is working with. It also depends on the restrictions imposed on the structural matrix to identify the model. The IRFs results are indicative that the persistence of the dynamic effects of fiscal policy is associated with whether the time series are unit-root or trend-stationary processes. In this subsection, it will be shown that the magnitude – and also persistence – also responds to the value chosen to restrict the output elasticity of taxes. The structural estimations of Figures [1] to [3] assumed that the output elasticity of taxes was equal to 2, i.e., that a positive 1 percent shock on output raises, contemporaneously, the tax receipts by 2 percent. This value is close, for example, to the estimated output-tax elasticity of US and Canada; and much higher than the values for United Kingdom, Germany and Australia – all of then calculated for the second half of the twentieth century (Perotti, 2004).

Figure 4 – Responses to tax shocks (alternative elasticities)

(a) Stochastic Trend *(b)* Trend-Stationarity

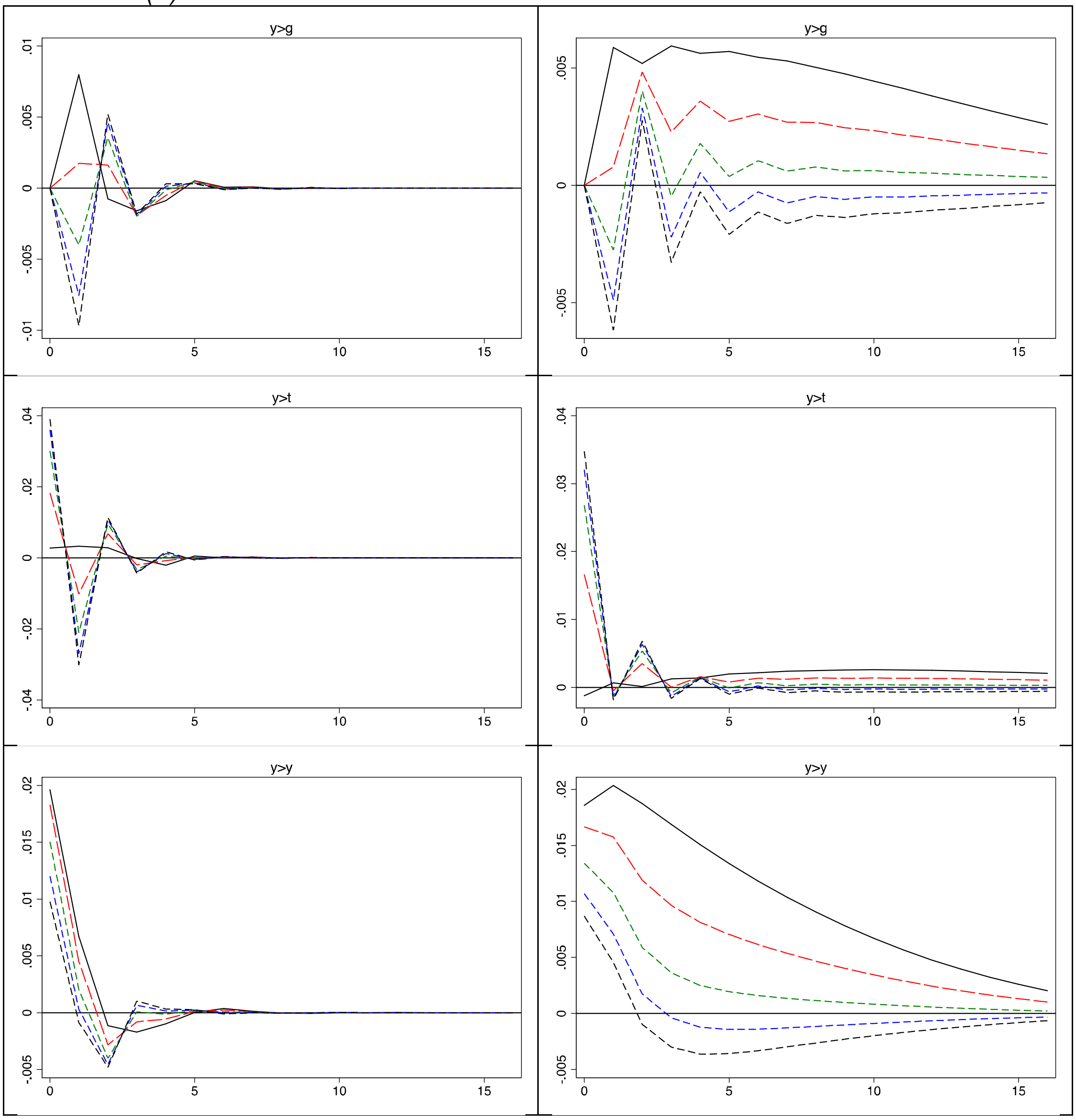


Source: Authors' calculations.

Note: **I)** the black solid line gives the recursive model IRFs. The dashed lines gives structural IRFs, each color representing a restricted value for the output-elasticity of taxes ($\beta_{\tau y}$): red ($\beta_{\tau y} = 1$); green ($\beta_{\tau y} = 2$); blue ($\beta_{\tau y} = 3$) and dark grey ($\beta_{\tau y} = 4$). **II)** Assumptions: panel (a) – stochastic trend (first-differentiated variables); panel (b) – deterministic trend (de-trended variables).

Figure 5 – Responses to output shocks (alternative elasticities)

(a) Stochastic Trend *(b)* Trend-Stationarity



Source: Authors' calculations.
Note: **I)** the black solid line gives the recursive model IRFs. The dashed lines gives structural IRFs, each color representing a restricted value for the output-elasticity of taxes ($\beta_{\tau y}$): red ($\beta_{\tau y} = 1$); green ($\beta_{\tau y} = 2$); blue ($\beta_{\tau y} = 3$) and dark grey ($\beta_{\tau y} = 4$). **II)** Assumptions: panel (a) – stochastic trend (first-differentiated variables); panel (b) – deterministic trend (de-trended variables).

In order to test, then, if changes in the choice of $\beta_{\tau y}$ will have consequences on the results, alternative elasticity values were tested, ranging from 1 to 4. The results are presented in Figures [4] and [5], which gives the responses to tax and output shocks, respectively. Alongside with the structural IRFs, the graphs also exhibit IRFs of a recursive model, with ordering going from spending, to output, to taxes.[17] The red, green, blue and grey dashed lines represent the responses assuming elasticity values of 1, 2, 3 and 4, respectively. The solid black line represents the recursive model. The responses of the spending shock were almost identical and therefore omitted.

Following the results of Figure [2], government-spending responses (Figure [4]) to positive tax shocks are statistically insignificant.[18] The sensibility analysis confirms that this result is independent of the choice of $\beta_{\tau y}$. But one can notice that there is a tendency of negative spending responses to tax shocks; and curiously, the structural identifications, with high output-tax elasticities, makes the negative response a bit stronger. Again, this could be a sign that tax hikes are generally associated with coordinated fiscal adjustments. Tax responses to its own shock varies inversely with the values of $\beta_{\tau y}$: under the stochastic trend assumption the impact response when $\beta_{\tau y} = 1$ is 25 percent higher than the benchmark ($\beta_{\tau y} = 2$); this value is 22 percent under trend-stationarity. If $\beta_{\tau y} = 4$, the impact responses are 39 and 33 percent smaller, respectively. The output response to tax shocks reveals very interesting patterns. The value of output-tax elasticity is the determinant factor for a significant response, at least at impact. Under the stochastic assumption, the recursive model has a initial response equal to zero by construction; the adoption of a high elasticity is essential for the negative response saw earlier (Figure [2]) and also in Figure [4] sensibility analysis. Moreover, the magnitude of the initial negative impact varies proportionally with the value of $\beta_{\tau y}$: when the elasticity is equal to 1, the impact response of output, still negative, but decrease by 44 percent. On the other hand, the increase of $\beta_{\tau y}$ to 4 makes the negative response to be 35 percent stronger – always in terms of the benchmark. Again, the responses under unit-root hypothesis tend to be of very short-run nature. Under trend-stationarity, the relation between the value of output-tax elasticity and the magnitude of initial response is the same: The initial negative response is 36 percent weaker when $\beta_{\tau y} = 1$ and 28 percent stronger

[17] The same ordering used by Cavalcanti and Silva (2010). This ordering probably the more theoretical sound of all alternatives using the recursive approach: it conserves at least two restriction of the model of Equation [3]. See Caldara and Kamps (2008).

[18] Complete graphs with impulse-response functions and confidence intervals are available upon request. The sensibility analysis graphs do not present the confidence intervals in order to make them more readable.

when $\beta_{\tau y} = 4$; after 5 quarters, though, the output response is practically the same in all structural-identified cases using the deterministic-trend assumption.

Figure [5] exhibits the responses to output shocks. Under both stochastic and deterministic assumptions, the spending response remains insignificant irrespective of the value of $\beta_{\tau y}$. However, the greater the elasticity value, the smaller will be the response, and if $\beta_{\tau y} > 1$, the initial response tends to be negative. This could be counterintuitive because of the fact that a high $\beta_{\tau y}$ would mean more receipts due to a positive output shock, improving the budget constraint of the government; but analyzing the output response to its own shock, one can realize that a high $\beta_{\tau y}$ tends to shorten the business cycle period, reducing the receipt gains. Under the stochastic assumption the output responses to its own shocks are generally short-lived, so the value of $\beta_{\tau y}$ is important more in relation to the magnitude of the impact response. In the case of trend-stationarity, the value of $\beta_{\tau y}$ makes much difference in shortening the cycle. Overall, the stochastic assumption IRFs indicate that the output's own response (on impact) is 22 percent stronger when $\beta_{\tau y} = 1$ and 35 percent weaker when $\beta_{\tau y} = 4$; under trend-stationarity, those values are 24 and 35 percent. The tax response to output shocks also depends positively on the magnitude of $\beta_{\tau y}$, but in both assumptions the IRFs do not present persistence. The recursive model shows insignificant response, highlighting the fact that the anti-cyclical fiscal policy is the result of the structural identification.

4 FINAL REMARKS

The objective of this study was to assess the effects of Brazilian fiscal policy on its economic activity, using quarterly data from the first quarter of 1995 to the first quarter of 2015. All the analysis was based on interpretation of impulse-response functions derived from a structural vector autoregressive model. The utilized model was composed of three endogenous variables: two fiscal policy instruments – government spending and government receipts – and the measure of economic activity (GDP). The identification strategy relied on outside information regarding output-tax elasticity and also on institutional reasoning that economic activity shocks cannot generate spending responses contemporaneously.

The analysis of the impulse-response functions brought some interesting results. Positive shocks on both spending and tax (receipts) generated negative output responses. This evidence is not too controversial: some works already found evidence of negative spending multipliers. Nevertheless, the fact that the trend-stationary model found this negative spending multiplier still significant after two or more years is relatively new. The negative impact of tax shocks is more in line with *a priori* reasoning. A more interesting finding regards the counter-cyclical behavior of fiscal responses due to output shocks – the result of a strong positive response of government receipts together with a insignificant response of spending – the result of the identification imposed on the structural model with its high output-tax elasticity: the counter-cyclical behavior of fiscal policy is not found when using the recursive model. Earlier works did not find this outcome, even applying vector autoregressive approach in a similar setting, indicating that more research should be spent on this issue. Due to the fact that earlier studies have found a highly pro-cyclical fiscal policy, it might be that the last observations are driving the results in the direction of counter-cyclicality. Lastly, and maybe more important, is the fact that the behavior of the estimated impulse-response functions differ greatly, depending on the assumption used regarding the nature of the trend. The transformations performed on the original time series – first-difference for the assumption of unit-root process, de-trend for the assumption of deterministic trend – generated very distinct dynamics, especially regarding the persistence of the responses to shocks. This result should be understood as evidence of the importance of serious analysis effort to uncover the true data generating process before actually estimating the model in applied research.

Notwithstanding, some words of caution are in order. As stressed earlier, the conclusions arrived here should be stated under qualifications about, especially, data limitation. The dataset used to estimate the responses of economic activity to fiscal shocks, and likewise, the behavior of fiscal policy in response to business cycles, is limited by the fact that it measures only the expenditures and receipts of the federal government through the fiscal execution of the National Treasury. Even though the whole purpose of this study is to infer some characteristics of the Brazilian fiscal policy in general, one has to have in mind that those assessments will be accurate insofar the fiscal policy movements of the rest of the public sector (social security expenditures, state and local expenditures and receipts) resembles the behavior of the federal government series used here. If, for instance, state and local governments behave, say, accommodating the federal government fiscal policy, then one should expect this hypothetical general government series as being quite distinct from the ones used here, and the conclusions of this study would, therefore, need revision.

Another issue with the actual data utilized in this study concerns the definitions used for the fiscal series. The international literature has been working with fiscal series netting out the so-called *automatic stabilizers*. This subtraction assures that especially the spending variable is incapable of responding to economic activity (critical assumption to structural identification). The implied assumption here is that beyond the fact that Brazilian fiscal policy is incapable of consciously respond to output in the short-run, the automatic response – due to spending structure relative to laws and procedures apart from conscious policy – are weak. Curiously, though, if this assumption is unrealistic, it would probably imply a negative contemporaneous impact of output on spending, contributing to a more negative response of spending to output shock and, consequently, to a more, and not less, counter-cyclical fiscal policy behavior. Likewise, receipts series should be net of potential automatic responses to business cycles. In this case, though, the sensibility analysis showed that even if the value of $\beta_{\tau y}$ used as reference is exaggerated, it would need to be so extensively in order to turn back the tax response (to output shocks) to insignificancy: cutting the value of output-tax elasticity by half still makes tax responses positive and significant at impact, and still makes output responses to tax shocks also significant, but negative, at impact. Still, much of this reasoning – about what would happen if more data were available, specially more suited definitions and perhaps more accurate output-elasticities – should be corroborated by empirical analysis. Advances and compilation of a more complete fiscal dataset is essential for further research.

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